

SECTION 1: DEVELOPMENT PROCESSES

1.1 PERFORMANCE MEASUREMENT PROCESS

1.1 Performance Measurement Process

Introduction

Performance measures are recognized as an important element of all Total Quality Management programs. Managers and supervisors directing the efforts of an organization or a group have a responsibility to know how, when, and where to institute a wide range of changes. These changes cannot be sensibly implemented without knowledge of the appropriate information upon which they are based. In addition, among many organizations within the Department of Energy (DOE) complex, there is currently no standardized approach to developing and implementing performance measurement systems. As a result, performance measures have not been fully adopted to gauge the success of the various quality management programs practiced by members of the Department of Energy Nevada Operations Office (DOE/NV) Family Quality Forum.

To address these issues, the steering committee members commissioned a work group to study the development, implementation, and operation of performance measurement systems. This guidance document, the product of the work group, provides a comprehensive, step-by-step explanation of how to develop performance measurements at any level within an organization and how to evaluate their effectiveness.

Appendix A contains a glossary of terms that may be used in this guidance document. The accompanying Case Study (Appendix B) illustrates a practical example of how to put the concepts of the guidance document to use. Appendix C contains examples of performance measurements that can be considered.

The implementation of performance measurements for a specific process should involve as many cognizant employees as possible to stimulate ideas and reinforce the notion that this is a team effort requiring buy-in from all involved in order to succeed. Substantial benefits are realized by organizations implementing performance measurement programs. These benefits are realized almost immediately through an improved understanding of processes by all employees. Furthermore, individuals get an opportunity to receive a broadened perspective of the organization's functions, rather than the more limited perspective of their own immediate span of control.

As a process, performance measurement is not simply concerned with collecting data associated with a predefined performance goal or standard. Performance measurement is better thought of as an overall management system involving prevention and detection aimed at achieving conformance of the work product or service to your customer's requirements. Additionally, it is concerned with process optimization through increased efficiency and effectiveness of the process or product. These actions occur in a continuous cycle, allowing options for expansion and improvement of the work process or product as better techniques are discovered and implemented.

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Performance measurement is primarily managing outcome, and one of its main purposes is to reduce or eliminate overall variation in the work product or process. The goal is to arrive at sound decisions about actions affecting the product or process and its output.

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What Are Performance Measures?

Performance measures quantitatively tell us something important about our products, services, and the processes that produce them. They are a tool to help us understand, manage, and improve what our organizations do. Performance measures let us know:

- how well we are doing
- if we are meeting our goals
- if our customers are satisfied
- if our processes are in statistical control
- if and where improvements are necessary.

They provide us with the information necessary to make intelligent decisions about what we do.

A performance measure is composed of a number and a unit of measure. The number gives us a magnitude (how much) and the unit gives the number a meaning (what). Performance measures are always tied to a goal or an objective (the target). Performance measures can be represented by single dimensional units like hours, meters, nanoseconds, dollars, number of reports, number of errors, number of CPR-certified employees, length of time to design hardware, etc. They can show the variation in a process or deviation from design specifications. Single-dimensional units of measure usually represent very basic and fundamental measures of some process or product.

More often, multidimensional units of measure are used. These are performance measures expressed as ratios of two or more fundamental units. These may be units like miles per gallon (a performance measure of fuel economy), number of accidents per million hours worked (a performance measure of the companies safety program), or number of on-time vendor deliveries per total number of vendor deliveries. Performance measures expressed this way almost always convey more information than the single-dimensional or single-unit performance measures. Ideally, performance measures should be expressed in units of measure that are the most meaningful to those who must use or make decisions based on those measures.

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Most performance measures can be grouped into one of the following six general categories. However, certain organizations may develop their own categories as appropriate depending on the organization's mission:

1. Effectiveness: A process characteristic indicating the degree to which the process output (work product) conforms to requirements. (Are we doing the right things?)
2. Efficiency: A process characteristic indicating the degree to which the process produces the required output at minimum resource cost. (Are we doing things right?)
3. Quality: The degree to which a product or service meets customer requirements and expectations.
4. Timeliness: Measures whether a unit of work was done correctly and on time. Criteria must be established to define what constitutes timeliness for a given unit of work. The criterion is usually based on customer requirements.
5. Productivity: The value added by the process divided by the value of the labor and capital consumed.
6. Safety: Measures the overall health of the organization and the working environment of its employees.

The following reflect the attributes of an ideal unit of measure:

- Reflects the customer's needs as well as our own
- Provides an agreed upon basis for decision making
- Is understandable
- Applies broadly
- May be interpreted uniformly
- Is compatible with existing sensors (a way to measure it exists)
- Is precise in interpreting the results
- Is economical to apply

Performance data must support the mission assignment(s) from the highest organizational level downward to the performance level. Therefore, the measurements that are used must reflect the assigned work at that level.

Within a system, units of measure should interconnect to form a pyramid (Figure 1.1). Technological units start at the base. These are measures of individual units of products and of individual elements of service.

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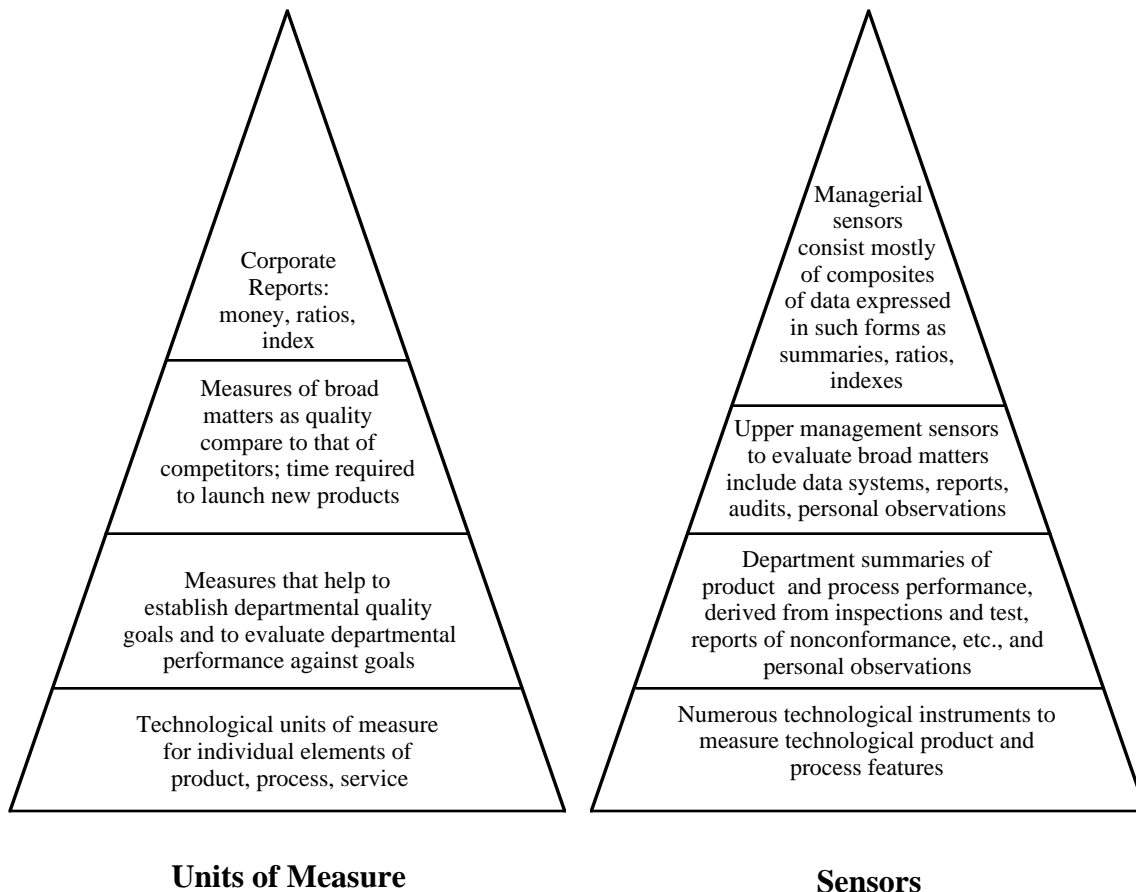
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The next level of units serve to summarize the basic data (e.g., percent defective for specific processes, documents, product components, service cycles, and persons.)

Next are units of measure that serve to express quality for entire departments, product lines, and classes of service. In large organizations, there may be multiple layers of this category.

At the top are the financial and upper management units (measures, indexes, ratios, etc.), which serve the needs of the highest levels in the organization: corporate, divisional, and functional.

Figure 1.1
Pyramid Used at All Levels of the Company



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What Are the Benefits of Measurements?

Listed below are seven important benefits of measurements:

1. To identify whether we are meeting customer requirements. How do we know that we are providing the services/products that our customers require?
2. To help us understand our processes. To confirm what we know or reveal what we don't know. Do we know where the problems are?
3. To ensure decisions are based on fact, not on emotion. Are our decisions based upon well-documented facts and figures or on intuition and gut feelings?
4. To show where improvements need to be made. Where can we do better? How can we improve?
5. To show if improvements actually happened. Do we have a clear picture?
6. To reveal problems that bias, emotion, and longevity cover up. If we have been doing our job for a long time without measurements, we might assume incorrectly that things are going well. (They may or may not be, but without measurements there is no way to tell.)
7. To identify whether suppliers are meeting our requirements. Do our suppliers know if our requirements are being met?

Why Do We Need to Measure?

If you cannot measure an activity, you cannot control it. If you cannot control it, you cannot manage it. Without dependable measurements, intelligent decisions cannot be made. Measurements, therefore, can be used for:

1. Control: Measurements help to reduce variation. For example, a typical control for DOE contractor accountability measurement is the Work Authorization Directive System (WADS) and Performance Evaluation Plan (PEP). Their purpose is to reduce expense overruns so that agreed-to objectives can be achieved.
2. Self-Assessment: Measurements can be used to assess how well a process is doing, including improvements that have been made.
3. Continuous Improvement: Measurements can be used to identify defect sources, process trends, and defect prevention, and to determine process efficiency and effectiveness, as well as opportunities for improvement.
4. Management Assessment: Without measurements there is no way to be certain we are meeting value-added objectives or that we are being effective and efficient. The basic concept of performance measurement involves (a) planning and meeting established operating goals/standards; (b) detecting deviations from planned levels of performance; and (c) restoring performance to the planned levels or achieving new levels of performance.

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What Is the Foundation for a Performance Measurement System?

Successful performance measurement systems adhere to the following principles:

1. Measure only what is important. Do not measure too much; measure things that impact customer satisfaction.
2. Focus on customer needs. Ask our customers if they think this is what we should measure.
3. Involve employees (workers) in the design and implementation of the measurement system. Give them a sense of ownership, which leads to improvements in the quality of the measurement system.

The basic feedback loop shown in Figure 1.2 presents a systematic series of steps for maintaining conformance to goals/standards by communicating performance data back to the responsible worker and/or decision maker to take appropriate action(s).

Without the basic feedback loop, no performance measurement system will ever ensure an effective and efficient operation, and, as a result, conformance to customers' requirements.

The message of the feedback loop is that to achieve the goal or standard, those responsible for managing the critical activity(ies) must always be in a position to know (a) what is to be done; (b) what is being done; (c) when to take corrective action; and (d) when to change the goal or standard.

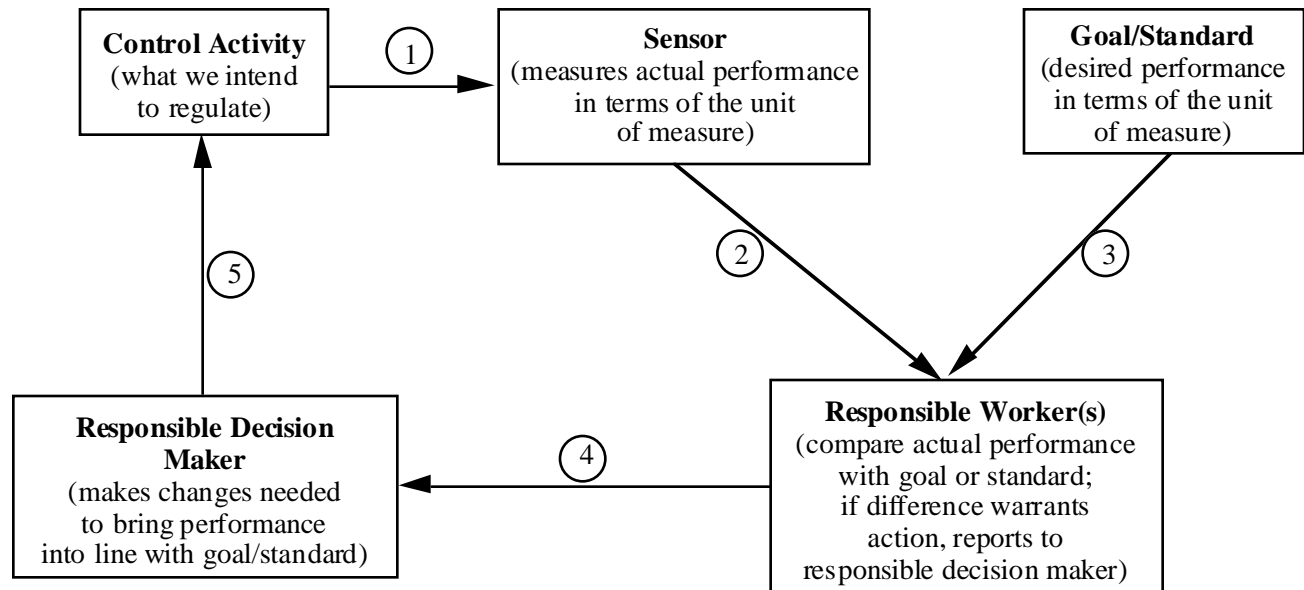
The basic elements of the feedback loop and their interrelations are:

1. The Sensor evaluates actual performance.
2. The Sensor reports this performance to a Responsible Worker.
3. The Responsible Worker also receives information on what the goal or standard is.
4. The Responsible Worker compares actual performance to the goal. If the difference warrants action, the worker reports to a Responsible Decision Maker. (This could signal a need for corrective action.)
5. The Responsible Decision Maker verifies variance, determines if corrective action is necessary, and, if so, makes the changes needed to bring performance back in line with the goals.

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*Figure 1.2
Basic Feedback Loop*



Process Overview

Figure 1.3 shows a high level block diagram of the performance measurement process. It has been separated into 11 discrete steps. This is a guideline, intended to show the process generically. Different organizations who best know their own internal processes should feel free to adapt the guidelines where necessary to best fit within their operations. Subcomponents within the steps may need to be exchanged, or it may be necessary to revisit completed steps of the process based on new information arising from latter steps.

A brief description of each of the process steps follows:

1. Identify the process flow. This is the first and perhaps most important step. If your employees cannot agree on their process(es), how can they effectively measure them or utilize the output of what they have measured?
2. Identify the critical activity to be measured. The critical activity is that culminating activity where it makes the most sense to locate a sensor and define an individual performance measure within a process.

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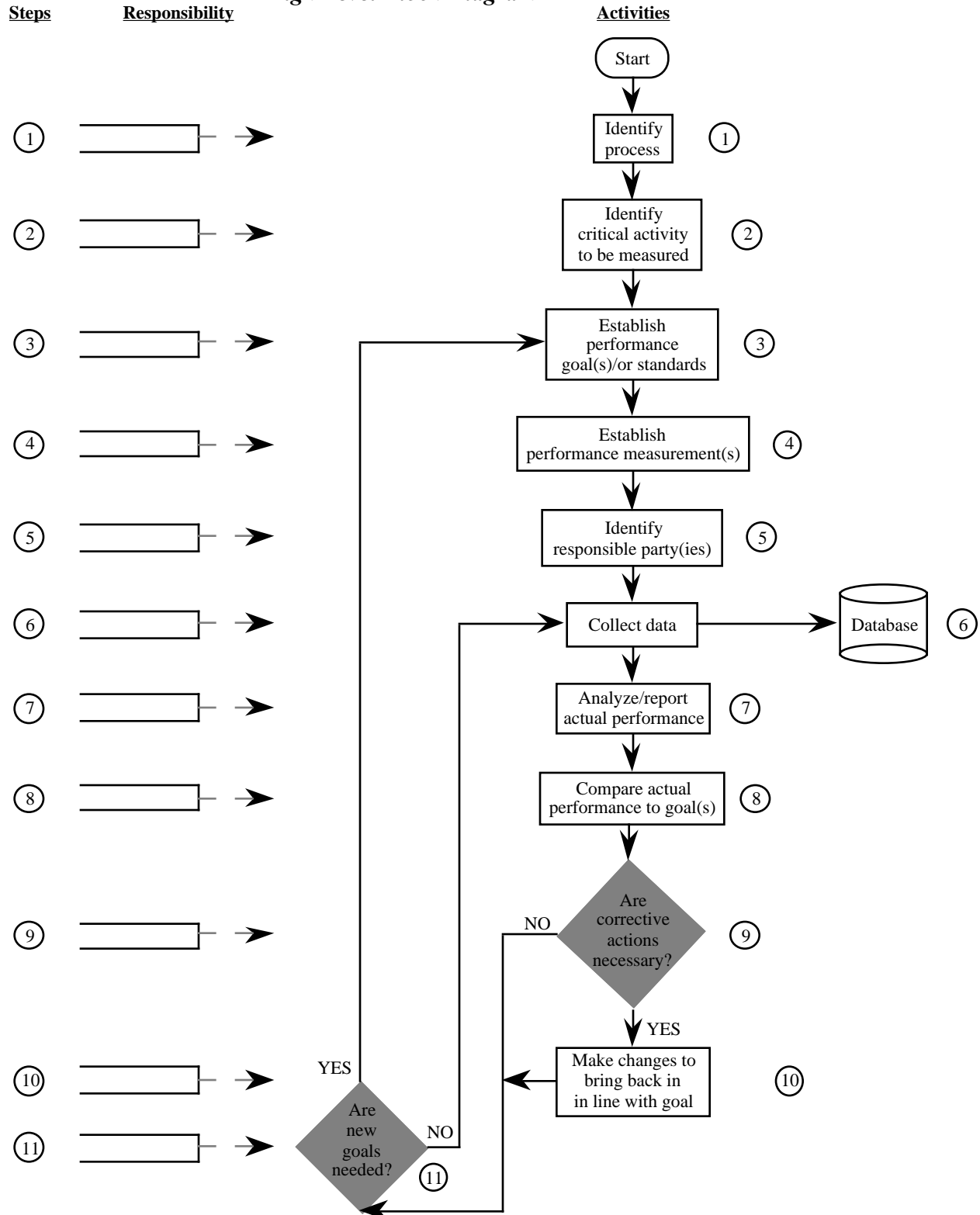
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3. Establish performance goal(s) or standards. All performance measures should be tied to a predefined goal or standard, even if the goal is at first somewhat subjective. Having goals and standards is the only way to meaningfully interpret the results of your measurements and gauge the success of your management systems.
4. Establish performance measurement(s). In this step, you continue to build the performance measurement system by identifying individual measures.
5. Identify responsible party(s). A specific entity (as in a team or an individual) needs to be assigned the responsibilities for each of the steps in the performance measurement process.
6. Collect data. In addition to writing down the numbers, the data need to be pre-analyzed in a timely fashion to observe any early trends and confirm the adequacy of your data collection system.
7. Analyze/report actual performance. In this step, the raw data are formally converted into performance measures, displayed in an understandable form, and disseminated in the form of a report.
8. Compare actual performance to goal(s). In this step, compare performance, as presented in the report, to predetermined goals or standards and determine the variation (if any).
9. Are corrective actions necessary? Depending on the magnitude of the variation between measurements and goals, some form of corrective action may be required.
10. Make changes to bring back in line with goal. This step only occurs if corrective action is expected to be necessary. The actual determination of the corrective action is part of the quality improvement process, not the performance measurement process. This step is primarily concerned with improvement of your management system.
11. Are new goals needed? Even in successful systems, changes may need to be revised in order to establish ones that challenge an organization's resources, but do not overtax them. Goals and standards need periodic evaluation to keep up with the latest organizational processes.

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Figure 1.3
Performance Measurement Process
High Level Block Diagram



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Step 1: Identify Process

In identifying the process, an understanding of what you want to measure is of critical importance. Usually there are many processes and functions, each potentially needing performance measures. If there are multiple processes, consider the business impacts, and select those processes that are most important to the customer (both internal and external) to satisfy their requirements and/or those processes with problem areas identified by management. These then become the key (or important) processes.

A process needs to be manageable in size. A lot of effort can be wasted if you do not start with a well-defined process. You should ask the following:

- A. What product or service do we produce?
- B. Who are our customer(s)?
- C. What comprises our process?
 - What do we do?
 - How do we do it?
 - What starts our process?
 - What ends our process?

Before you try to control a process, you must understand it. A flow diagram is an invaluable tool and the best way to understand a process. Flowcharting the entire process, down to the task level, sets the stage for developing performance measures.

All parties who are involved in the process should participate in creating the flowcharts. In a team environment, individuals will receive a new understanding of their processes. As participants, you can count on their later support to make the performance measurement system work.

***OUTPUT: A LIST OF PROCESSES, KEY PROCESSES, AND
FLOW DIAGRAMS FOR THESE KEY
PROCESSES.***

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Step 2: Identify Critical Activity(ies) to be Measured

It is important to choose only the critical activity(ies) to be measured. We measure these activities to control them. Controlling, or keeping things on course, is not something we do in the abstract. Control is applied to a specific critical activity. When making your selection, focus on key areas and processes rather than people.

Examine each activity in the process and identify those that are critical. Critical activities are those that significantly impact total process efficiency, effectiveness, quality, timeliness, productivity, or safety. At the management level, critical activities impact management priorities, organizational goals, and external customer goals.

Ask the following: Does it relate, directly or indirectly, to the ultimate goal of customer satisfaction? Every critical activity should. For example, on-time delivery is directly related to customer satisfaction. Use quality tools such as the Pareto principle, brainstorming, or examining data to help prioritize the critical activities.

Confirm that the activity is critical. Do all concerned agree that this activity needs to be watched closely and acted on if its performance is less than desirable? Is it something that should be continuously improved? Does the benefit exceed the cost of taking the measurement? If the answer is "no" to any of these questions, you should reevaluate why you consider it critical.

Each critical activity becomes the hub around which a feedback loop is constructed. (Figure 1.2)

It is at this step you begin to think about what you want to know or understand about the critical activity and/or process. Perhaps the most fundamental step in establishing any measurement system is answering the question, "What do I want to know." The key issue then becomes, "How do we generate useful information?" Learning to ask the right questions is a key skill in effective data collection. Accurate, precise data collected through an elaborately designed statistical sampling plan is useless if it does not clearly address a question that someone cares about. It is crucial to be able to state precisely what it is you want to know about the activity you are going to measure. Without this knowledge, there is no basis for making measurements.

To generate useful information, planning for good data collection proceeds along the following lines:

- What question do we need to answer?
- How will we recognize and communicate the answers to the question?
- What data-analysis tools (Pareto diagram, histogram, bar graph, control charts, etc.) do we envision using? How will we communicate the results?
- What type of data do the data analysis tools require?

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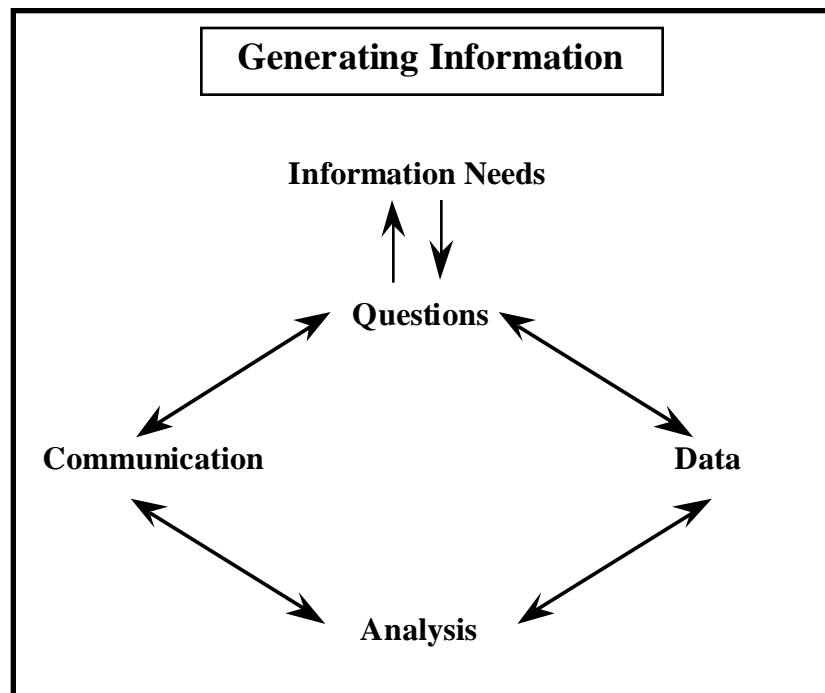
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- Where in the process can we get these data?
- Who in the process can give us these data?
- How can we collect these data from people with minimum effort and chance of error?
- What additional information do we need to capture for future analysis, reference, and tractability?

Notice how this planning process (Figure 1.4) essentially works backward through the model for generating useful information. We start by defining the question. Then, rather than diving into the details of data collection, we consider how we might communicate the answer to the question and what types of analysis we will need to perform. This helps us define our data needs and clarifies what characteristics are most important in the data. With this understanding as a foundation, we can deal more coherently with the where, who, how, and what else issue of data collection.

OUTPUT: A LIST OF THE CRITICAL ACTIVITY AREAS FOR THE KEY PROCESS.

Figure 1.4
Model for Generating Useful Information



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Information generation begins and ends with questions. To generate information, we need to:

- Formulate precisely the question we are trying to answer.
- Collect the data and facts relating to that question.
- Analyze the data to determine the factual answer to the question.
- Present the data in a way that clearly communicates the answer to the question.

Step 3: Establish Performance Goal(s) or Standard(s)

Goals and standards are necessary; otherwise there is no logical basis for choosing what to measure, what decisions to make, or what action to take. Goals can be a management directive or can be set in response to customer needs or complaints. Know your customers and their expectations. For each critical activity selected for measurement, it is necessary to establish a performance goal or standard. This is an "aimed-at" target, an achievement toward which effort is expended. Standards often are mandated by external sources (e.g., Occupational Safety and Health Administration [OSHA], government regulations, etc.). Knowledge of performance is not enough; you must have a basis for comparison before you can decide or act.

The concept of establishing performance goals/standards is not limited to numbered quantities, i.e., budget, deliveries. Neither is it limited to "things." The concept of standards extends to business practices, routines, methods, and procedures as well.

Performance goals can be established for (1) the overall process output, and/or, (2) the critical activities that produce the output. In any case, if this is the first set of goals or standards to be established, and no basis for setting goals or standards exists, a baseline period of observation is appropriate prior to establishing the goal or standard.

Good performance goals or standards are:

- Attainable: Should be met with reasonable effort under the conditions that are expected to prevail.
- Economic: Cost of setting and administering should be low in relation to the activity covered.
- Applicable: Should fit the conditions under which they are to be used. If conditions vary, should contain built-in flexibility to meet these variables.
- Consistent: Should help to unify communication and operations throughout all functions of the company.

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- All-inclusive: Should cover all interrelated activities. Failing this, standards will be met at the expense of those activities for which standards have not been set.
- Understandable: Should be expressed in simple, clear terms, so as to avoid misinterpretation or vagueness. Instructions for use should be specific and complete.
- Measurable: Should be able to communicate with precision.
- Stable: Should have a long enough life to provide predictability and to amortize the effort of preparing them.
- Adaptable: Should be designed so that elements can be added, changed, and brought up to date without redoing the entire structure.
- Legitimate: Should be officially approved.
- Equitable: Should be accepted as a fair basis for comparison by the people who have the job of meeting the goal or standard.
- Customer Focus: Should address areas important to the customer (internal/external) such as cycle time, quality, cost schedule performance, and customer satisfaction.

***OUTPUT: A LIST OF GOALS FOR EACH CRITICAL
ACTIVITY WITHIN THE PROCESS***

Step 4: Establish Performance Measurement(s)

This step involves performing several activities that will continue to build the performance measurement system. Each performance measurement consists of a defined unit of measure (the performance measure itself), a sensor to measure or record the raw data, and a frequency with which the measurements are made. To develop a measure, the team performs the following activities:

- translates “what do I want to know” into a performance measure
- identifies the raw data that will generate the performance measure
- determines where to locate the raw data
- identifies the sensor or measurement instrument that will collect the data for the performance measures
- determines how often to make the measurements

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At this point, your team has agreed upon which process to measure (Step 1), identified the critical activities of your process with emphasis on those that impact quality, efficiency, timeliness, customer satisfaction, etc. (Step 2), looked at goals for these activities, products, and services (where they exist), and has quantified these goals where possible (Step 3). Your team should use the knowledge gained from these previous steps to help state precisely what you want to know about the critical activities or the process as a whole. Think of this step as one that will allow you to generate useful information rather than just generating data. The purpose of this information is to provide everyone involved with an agreed-upon basis for making sensible decisions about your processes, products, and services. Don't move on until the team agrees on what information you are trying to extract from the measurements.

Translate into Performance Measures

Having identified precisely what you want to know or understand about your process, you must now assemble this knowledge into a performance measure. Performance measures, and the data necessary to generate them, should be chosen to answer the questions you have just posed above. At this point, your team must decide how you will "say it in numbers."

Performance measures are generally easiest to determine for activities or processes that have established and quantified goals. In such cases, the performance measures are usually stated in the same units as or similar units to the goals.

When no goals exist for an activity (or the process as a whole), the team should revisit the fundamental question of what it is they wish to know. The performance measures should provide quantitative answers to their questions in units that relate to those questions. The team may wish to reread **What Are Performance Measures?** on Page 1 - 4 to reinforce the concept of a unit of measure and what it should convey.

The following example of a vendor selection process should prove useful in illustrating how to turn a question posed into one of a possible performance measure:

You are part of a work team within the procurement department of your company. Over the years the number of vendors from which you make purchases has grown astronomically and you need some basis upon which to help decide which vendors perform the best. You have concluded that one of the more fundamental questions you would like to answer is "how well do our vendors meet the contract delivery dates?" Your team needs to choose a performance measure that will help answer this question. After putting several possible performance measures on a flip chart and examining what information each could convey, the team decided to use:

% on-time deliveries per month

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To ensure the team understood what this measure will provide them, they rewrote this measure in terms of the units that are actually used to calculate it. The performance measure then looks like this:

$$\frac{\text{number of on-time deliveries per month}}{\text{total number of deliveries per month}} \times 100\%$$

Both versions of the performance measure are essentially the same, but the second actually conveys more information to the reader and provides an indication of what data goes into the measurement. This performance measure should help the team answer the question of how well vendors are meeting contract delivery dates. By writing their performance measure in more fundamental units, the team will be better prepared to move to the next activity, which is identifying the raw data needed.

A good way to “test” a team’s understanding of the performance measures they have chosen is to have them describe how they would display their results graphically. Have the team explain what type of graph they would use for each performance measure and how they would interpret the results. Quite often, seeing a performance measure displayed graphically will help determine if it will actually provide the information needed. Doing this simple step now will help ensure the team that it has chosen the right performance measure.

In reality, many work teams may find that some of their performance measures do not really tell them what they want to know. Don’t panic, even performance measures that don’t quite work may help refocus the team on the real issues they hope to address. Introduce a new set of measures and try again.

Identify the Raw Data

The purpose of this activity is to identify the raw data you will need to generate the performance measures. It is difficult to perform a measurement if the needed data and data source have not been identified. For very simple processes with straightforward performance measures, this step may seem simple. However, very complex or high-level performance measures may require many raw data from numerous sources. In general, performance measures are seldom generated directly in a single measurement or from a single source. They usually (but not always) consist of some combination of other raw data elements as in the example above. To illustrate the difference, consider the following examples:

1. Your workgroup enters data from customer order forms into an electronic database. Your group decided that the number of errors per day was a useful performance measure for that process. The raw data for your measurement consist of counting the errors in the database each day. In this case, the collection of raw data needed is the performance measure and it has been measured directly.

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2. You are in the procurement department and your team has decided to use the percent of on-time deliveries per month of key vendors as a performance measure. The raw data you need consist of four sets. First, you need the delivery date on the contract that was awarded to your vendors. Second, you need the date the delivery was made. Third, you must compute if the delivery was on time and count how many deliveries there were for each vendor. Fourth, the team will need the total number of deliveries made within the month for that vendor. Unlike example 1, several elements of raw data are required to reconstruct the performance measure.
3. Your management team considers the company's overhead burden rate to be an excellent high-level performance measure. This measure is very complex and is frequently performed by the company's accountants and budget analysts. Such measures require many raw data elements that consist of facilities costs, human resource benefits, training costs, rework costs, sales income, and so on. This performance measure requires that many lower level measures are taken and "rolled up" into the higher level measure. Many data elements must be collected along the way.

When the team completes this activity, it should have a list of the raw data elements needed to generate the performance measures. In addition, the team should consider what, if any, computations or calculations must be performed with or on the data.

Locate the Raw Data

The purpose of this activity is to determine if and where the data exist. Stated differently, it's a matter of locating at what step in a process to make a measurement, at what point in time, or at what physical or geographical location. Quite often, this activity is performed concurrently with the previous one.

In the simplest case you may find that your work group already has the raw data collected and you need only retrieve in order to generate the associated performance measure. In other cases, the data you need may have been collected by another department. For instance, in Example 2 above, the delivery date was probably collected by the Shipping and Receiving Department. Examine the data you need and determine if your own work group, department, or an external group is already collecting it.

If the data do not presently exist, the team will have to determine where to find it. The process of locating it is generally quite straightforward. This is particularly true if the team is measuring its own process. The measurement point is usually located at or near each critical activity that was identified in Step 2. This is generally the case if your performance measure is measuring an activity within the process rather than the overall process itself. For performance measures that assess some overall aspect of a process, the collection point usually occurs at the culmination of a process.

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More global performance measures generally require data from many sources as in Example 3 above. Before proceeding, the team must determine where the data are located, or where in the process, at what point in time, and at what physical location the data will be collected.

Continuing with the procurement example, we would probably find something like the following take place:

The team has determined what raw data they will need to construct their performance measure and now they must locate the data. In this example the process is rather simple. The contract delivery date is recorded within the procurement department itself on several documents and within a database so that retrieval will be trivial. The second data element is recorded by the Shipping and Receiving department and is likewise simple to extract. All that remains to reconstruct the performance measure are the computations with the data.

Identify the Sensor

By this point, the team has determined what raw data they require, where it is located, and where it will be collected. To proceed, they must determine how they will actually measure or collect what they need. A sensor is required to accomplish the measurement.

A sensor is a device or person that is able to detect (sense) the presence or absence of some phenomena and (generally) provide a reading of the intensity (how much) of that phenomena in a quantifiable form with the appropriate units of measure. The sensor is what or who will do the measuring or data collection for your measurement system.

Sensors take many forms depending on what they are designed to measure. For technical and manufacturing processes, there are sensors that can accurately measure length (micrometer), temperature (thermocouple), voltage (digital voltmeter or digitizer), and so on. For less technical processes there are databases, log books, time cards, and checksheets. In some cases, the sensor makes a measurement and a person records the results. In other cases, only a human is capable of “sensing” some phenomena and some other device is used to record the result. Many inspection activities can only be performed by humans. There are also automated data collection systems or sensors that require no human intervention other than calibration or maintenance. Many manufacturing processes employ such sensors to detect, measure, and record the presence of nonstandard products.

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Choosing a sensor usually involves asking simple questions about the measurement you hope to make:

1. What am I trying to measure; what kind of data are they?
2. Where will I make the measurement; where are the data?
3. Am I simply trying to measure the presence or absence of some feature? (Was the order placed, was the report delivered? Did the computer help desk solve the problem?)
4. Do I need to sense the degree or magnitude of some feature or count how many?
5. How accurate and precise must my measurements be?
6. Do the measurements occur at a particular point in time or space?

In most cases, the sensor will be rather obvious, but the team should be prepared to give some thought to how they will measure and collect their data. For instance, the need for accuracy and/or precision may rule out certain sensors. If you rely on a human as a sensor, you must consider all the possible biases that are inherent in human sensors. Step 6 discusses biases and their potential solutions. Replacing human sensors with technological instruments may be the best solution if a particularly critical measurement requires unusual accuracy or precision.

When the team completes this step, it should have a sensor identified for each raw data element and should have determined where the sensor will be deployed.

The procurement team determined that the sensor for their first data element (contract delivery date) would be the “buyer’s diary,” an electronic database maintained by each buyer in company-supported software. The second sensor was determined to be the “receiving log,” which was maintained at the receiving dock by a receiving clerk. This sensor provided the actual delivery date for each order. Having identified the sensors, the team could now acquire the necessary data.

Determine How Often to Make Measurements

In this last activity, the team will determine how often measurements should be made. In a sense, there are two distinct types of measures taken when a performance measurement system is adopted. One type of measure is the performance measure itself. This measure is generally taken (calculated) and reported over some regular or repeating time interval. In the procurement example, the performance measure is calculated and presumably reported at a frequency of once per month. Some performance measures are used to observe real-time trends in a process and may be measured and plotted daily. In general, the frequency of measurement for the performance measure is usually determined when the performance measure itself is determined. Often the unit of measure chosen as the performance measure contains or alludes to the frequency of measurement.

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The other measure that should be addressed is that of the raw data itself. The frequency with which raw data are collected or measured may have a significant impact upon the interpretation of the performance measure. For some performance measures, this amounts to asking how many data are needed to make the measure valid or statistically significant. Each team or manager will have to determine how often measurements must be made (data taken) to ensure statistical significance and believable results.

Again, using the procurement example, the raw data for this measure are each time a buyer enters contract data into the database and each time the receiving clerk logs in a delivery. It could be said then that the frequency of measurement or data collection is continuous; that is data are rewarded each time a transaction or delivery occurs.

Processes that are repeated numerous times per hour or may only require a sample measure of every tenth event or so. Other events, like the procurement example, are measured or recorded each time they happen. Teams should use their best judgment in choosing the frequency of data collection and should consult the company's statistician or quality consultant if there is some question.

OUTPUT: THE PERFORMANCE MEASURE AND ITS COMPONENTS

Step 5: Identify Responsible Party(ies)

Steps 1 through 4 are primarily team activities. To continue the performance measurement process, the responsible worker(s) and the responsible decision maker must be defined. (In some instances, one person may be responsible for the entire system.) It is now appropriate to determine who should:

- Collect the data
- Analyze/report actual performance
- Compare actual performance to goal/standard
- Determine if corrective action is necessary
- Make changes

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Ideally, responsibility should be assigned to individuals commensurate with authority. This means that each responsible party should:

1. Know what the goals are
2. Know what the actual performance is
3. Have the authority to implement changes if performance does not conform to goals and standards

To hold someone responsible in the absence of authority prevents them from performing their job and creates the risk of unwarranted blame.

OUTPUT: A LIST OF PEOPLE AND THEIR AREAS OF RESPONSIBILITY.

Step 6: Collect Data

The determination of conformance depends on meaningful and valid data. Before you start out to collect a lot of new data, it is always wise to look at the data you already have to make certain you have extracted all the information you can from it. In addition, you may wish to refer back to Step 2 and review planning for good data collection.

Information, as a term, comprises the answers to your questions. Data are a set of facts presented in quantitative or descriptive form. Obviously, data must be specific enough to provide you with relevant information. There are two basic kinds of data:

- Measured or variables data: Data that may take on any value within some range. This type of data provides a more detailed history of your business process. This involves collecting numeric values that quantify a measurement and therefore require small samples. If the data set is potentially large, consider recording a representative sample for this type of data.

Examples:

- ◇ Cost of overnight mail
- ◇ Dollar value of stock
- ◇ Number of days it takes to solve a problem
- ◇ Diameter of a shaft

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- ◊ Number of hours to process an engineering change request
- ◊ Number of errors on a letter
- Counted or attribute data: Data that may take on only discrete values. Attribute data need not be numeric. These kinds of data are counted, not measured, and generally require large sample sizes to be useful. Counting methods include defective/nondefective; yes/no; accept/reject.

Examples

- ◊ Was the letter typed with no errors?
- ◊ Did the meeting start on time?
- ◊ Was the phone answered by the second ring?
- ◊ Was the report turned in on schedule?

A system owner needs to supervise the data collection process to determine if the data is being collected properly; if people are doing their assignments. Some form of preliminary analysis is necessary during the data collection process. Is your measurement system functioning as designed? Check the frequency of data collection. Is it often enough? Is it too often? Make adjustments as necessary and provide feedback to the data collectors.

Data Collection Forms

There are two types of forms commonly used to aid in data collection. Often combinations of these are used:

- Checksheet: A form specially designed so that the results can be readily interpreted from the form itself. This form of data collection is ideal for capturing special (worker controlled) cause of process variation since the worker can interpret the results and take corrective actions immediately.
- Data Sheet: A form designed to collect data in a simple tabular or column format (often related to time-dependent data). Specific bits of data—numbers, words, or marks—are entered in spaces on the sheet. As a result, additional processing is typically required after the data are collected in order to construct the tool needed for analysis. This form of data collection is usually used for capturing common (manager controlled) causes of process variations.

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Data Collection System

This system ensures that all of our measurements are collected and stored. The type of data and frequency of measurement will help you determine how to collect it. Some data fit well into check sheets or data sheets that collect information in simple tabular or columnar format.

Other measurements lend themselves to easy entry into a computer database. Whatever system is chosen should provide easy access and be understandable by those who are tasked with reviewing the data. Those tasked with performing the data collection should understand the data collection system, have the necessary forms at hand, be trained in the data collection, and have access to instructions pertaining to the system.

The data collected needs to be accurate. Inaccurate data may give the wrong answer to our information questions. One of the most troublesome sources of error is called bias. It is important to understand bias and to allow for this during the development and implementation of any data collection system. Design of data collection forms and processes can reduce bias. Some types of biases that may occur:

- Exclusion—some part of the process or the data has been left out of the data collection process
- Interaction—the data collection itself interferes with the process it is measuring
- Perception—the data collector biases (distorts) the data
- Operational—the data collection procedures were not followed or were specified incorrectly or ambiguously
- Nonresponse—some of the data are missing or not obtained
- Estimation—statistical biases
- Collection time period—the time period or frequency selected for data collection distorts the data, typically by missing significant events or cyclic occurrences.

OUTPUT: A GROWING LIST OF DATA. DATA SHOULD BE MONITORED AS THEY ARE BEING COLLECTED.

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Step 7: Analyze/Report Actual Performance

Before drawing conclusions from the data, you should verify that the data collection process has met the following requirements:

- Review the information questions that were originally asked. Do the data collected still appear to answer those questions?
- Is there any evidence of bias in the collecting process?
- Is the number of observations collected the number specified? If not, why?
- Do you have enough data to draw meaningful conclusions?

Once the raw data are collected and verified, it is time for analysis. In most instances, your recorded data are not necessarily the actual performance measurement. Performance measurements are usually formulated based on one or more raw data inputs. Therefore, you need to assemble the raw data into a performance measurement.

The next step in analyzing data is deciding how you are going to present or display the data. You usually group the data in a form that makes it easier to draw conclusions. This grouping or summarizing may take several forms: tabulation, graphs, or statistical comparisons. Sometimes, single data grouping will suffice for the purposes of decision making. In more complex cases, and especially where larger amounts of data must be dealt with, multiple groupings are essential for creating a clear base for analysis.

After summarizing your data, you develop your report. A number of tools are available to assist you. Below are some of the more widely used tools and concepts to help you in your reporting.

- Use spread sheets and databases as appropriate to organize and categorize the data and to graphically show the trends. This will greatly improve the ease and quality of interpretation. Some of the more common graphic presentations are histograms, bar charts, pie charts, scatter diagrams, and control charts.
- Make the report comparative to the goals.
- Make use of summaries. The common purpose is to present a single important total rather than many subtotals. Through this summary, the reader is able to understand enough to judge whether to go into detail or to skip on to the next summary.
- Be aware of pitfalls in your data presentation. Averaging your data on a monthly basis might shorten the amount of information presented, but could hide variations within the monthly period. Choices of scales on graphs and plots could skew interpretation.

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- Standardize the calendar so that the month begins and ends uniformly for all reports. Failing this, the relation of cause to effect is influenced by the fact that events tend to congest at the end of the reporting period.
- Adopt a standard format. Use the same size of sheets or charts. As far as possible, use the same scales and headings.

Reports may take many forms. However, at this stage, the report is intended to be a status transfer of information to the responsible decision maker for the process. Therefore, the report will likely consist of sets of tables or charts that track the performance measures, supplemented with basic conclusions.

OUTPUT: A PRESENTATION OF THE DATA IN THE FORM OF A REPORT.

Step 8: Compare Actual Performance to Goal/Standard

Within their span of control, responsible workers compare actual performance with the goal or standard. If variance warrants action, a report is made to the responsible decision maker.

Once the comparison against the goal or standard is initially established, you have several alternatives available for possible actions. You can decide to:

- Forget it. Variance is not significant.
- Fix it. (Step 9 and 10)
- Challenge the goal or standard. (Step 11)

If there is no significant variance, then continue the data collection cycle. If there is a variance between the goal and the performance measure, look at the magnitude. If it is significant, report to the decision maker. If a decision to implement a corrective action is warranted, go to Step 9.

OUTPUT: DECISION BASED ON PERFORMANCE VARIANCE.

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Step 9: Determine if Corrective Action(s) is Necessary

Step 9 is a decision step. You can either change the process or change the goal. If the variance is large, you may have a problem with your process and will need to make corrections to bring the performance back into line with the desired goal or standard. To address these potential problems, you can form a quality improvement team or do a root cause analysis to evaluate. Consider, too, that the goal may have been unrealistic.

If the variance is small, your process is probably in good shape. But, you should consider reevaluating your goals to make them more challenging. In addition, if you do make changes to the process, you will need to reevaluate goals to make sure they are still viable.

The key objectives of correction are:

1. To remove defects; in many cases this is worker-controllable.
2. To remove the cause of defects. Dependent upon the defect cause, this may be worker or management controllable.
3. To attain a new state of process performance, one that will prevent defects from happening.
4. To maintain or enhance the efficiency and effectiveness of the process. This is an essential condition for continuing process improvement and ultimately increasing the competitiveness and profitability of the business itself.

OUTPUT: ACTION PLAN TO IMPLEMENT CHANGES OR REEVALUATE GOALS (STEP 11).

Step 10: Make Changes to Bring Process Back in Line with Goal or Standard

This is the final step in closing the feedback loop: Making changes to bring the process back in line with the goal or standard. Changes comprise a number of actions that are carried out to achieve one or more of the correction objectives listed in Step 9.

The prime result of these corrective actions should be removal of all identified causes of defects resulting in an improved or a new process.

OUTPUT: A SUCCESSFULLY IMPLEMENTED PLAN.

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Step 11: Determine if New Goals or Measures are Needed

The decision to create new performance measures or goals will depend on three major factors:

1. The degree of success in achieving previous objectives.
2. The extent of any change to the scope of the work processes.
3. The adequacy of current measures to communicate improvement status relative to critical work processes.

Goals need to be challenging, but also realistically achievable. If previously set objectives were attained with great difficulty, or not reached at all, then it may be reasonable to re-adjust expectations. This also applies to the objectives that were too easily met. Extensive scope changes to the work processes will also necessitate establishing new performance measures and goals. Changes in performance measures and goals should be considered annually and integrated into planning and budgeting activities.

OUTPUT: NEW GOALS, MEASURES, OR NO CHANGE.

GLOSSARY: These definitions apply to terminologies used in Section 1.0 Development Processes:

Accuracy: The closeness of a measurement to the accepted true value. The smaller the difference between the measurement and the true value, the more accurate the measurement.

Attribute Data: Data that may take on only discrete values; they need not be numeric. These kinds of data are counted, not measured, and generally require large sample sizes to be useful.

Bias (of measurement): A tendency or inclination of outlook that is a troublesome source of error in human sensing.

Checksheet: A form specially designed so that results can be readily interpreted from the form itself.

Continuous Improvement: The ongoing improvement of products, services, and processes through incremental and measurable enhancements.

Control: The set of activities employed to detect and correct variation in order to maintain or restore a desired state of conformance with quality goals.

Corrective Action: Measures taken to rectify conditions adverse to quality and, where necessary, to preclude repetition.

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Critical Activity: Activity(ies) that significantly impact total process efficiency, effectiveness, quality, timeliness, productivity, or safety. At the management level, they impact management priorities, organizational goals, and external customer goals.

Customer: An entity that receives products, services, or deliverables. Customers may be either internal or external.

Data: Information or a set of facts presented in descriptive form. There are two basic kinds of data: measured (also known as variables data) and counted (also known as attribute data).

Data Collection System: A broadly defined term indicating that set of equipment, log books, data sheets, and personnel used to record and store the information required to generate the performance measurements of a process.

Data Sheet: A form designed to collect data in a simple tabular or column format. Specific bits of data—numbers, words, or marks—are entered in spaces on the sheet. Additional processing is typically required after the data are collected in order to construct the tool needed for analysis.

Defect: A nonconformance to the product quality goals; it leads to customer dissatisfaction.

DOE/NV Family: DOE/NV, DOE/NV Contractors, and users of DOE/NV facilities.

Effectiveness: A process characteristic indicating the degree to which the process output (work product) conforms to requirements.

Efficiency: A process characteristic indicating the degree to which the process produces the required output at minimum cost.

Feedback: Communication of quality performance to sources that can take appropriate action.

Feedback Loop: A systematic series of steps for maintaining conformance to quality goals by feeding back performance data for evaluation and corrective action. This is the basic mechanism for quality control.

Frequency: One of the components of a performance measurement that indicates how often the measurement is made.

Goal: A statement of attainment/achievement that is proposed to be accomplished or attained with an implication of sustained effort and energy.

Management Assessment: The determination of the appropriateness, thoroughness, and effectiveness of management processes.

Optimum: A planned result that meets the needs of customer and supplier alike, meets competition, and minimizes the customer's and supplier's combined costs.

Organization: Any program, facility, operation, or division.

Performance Measure: A generic term encompassing the quantitative basis by which objectives are established and performance is assessed and gauged. Performance measures include performance objectives and criteria (POCs), performance indicators, and any other means that evaluate the success in achieving a specified goal.

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Performance Measurement Category: An organizationally dependent grouping of related performance measures that convey a characteristic of a process, such as cycle time.

Performance Measurement System: The organized means of defining, collecting, analyzing, reporting, and making decisions regarding all performance measures within a process.

Precision: The closeness of a group of repeated measurements, to their mean value. The smaller the difference between the group of repeat measurements and the mean value, the more precise the instrument. Precision is an indicator of the repeatability, or consistency, of the measurement.

Process: Any activity or group of activities that takes an input, adds value to it, and provides an output to a customer. The logical organization of people, materials, energy, equipment, and procedures into work activities designed to produce a specified end result (work product).

Productivity: The value added by the process divided by the value of the labor and capital consumed.

Quality: The degree to which a product or service meets customer requirements and expectations.

Raw Data: Data not processed or interpreted.

Safety: Measures the overall health of the organization and the working environment of its employees.

Self Assessment: The continuous process of comparing performance with desired objectives to identify opportunities for improvement. Assessments conducted by individuals, groups, or organizations relating to their own work.

Sensor: A specialized detecting device designed to recognize the presence and intensity of certain phenomena and to convert this sensed knowledge into information.

Timeliness: Measures whether a unit of work was done correctly and on time. Criteria must be established to define what constitutes timeliness for a given unit of work. The criterion is usually based on customer requirements.

Unit of Measure: A defined amount of some quality feature that permits evaluation of that feature in numbers.

Validation: A determination that an improvement action is functioning as designed and has eliminated the specific issue for which it was designed.

Variable Data: Data that may take on any value within some range. It provides a more detailed history of a business process. This involves collecting numeric values that quantify a measurement and therefore requires small samples.

Variance: In quality management terminology, any nonconformance to specification.

Verification: The determination that an improvement action has been implemented as designed.

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Worker Controllable: A state in which the worker possesses: (1) the means of knowing what is the quality goal; (2) the means of knowing what is the actual quality performance; and (3) the means of changing performance in the event of nonconformance.

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